Europa Clipper Science Traceability Matrix

Goal	Objective	Investigation		Measurement		Model Instrument	Mission constraints/requirements	Version update notes	Water	Chemistry	Energy
Explore Europa to investigate its habitability	IO. Ice Shell and Ocean Characterize the ice shell and any subsurface water, including their heterogeneity, ocean properties, and the nature of surface-ice-ocean exchange.	IO.1	Characterize the distribution of any shallow subsurface water and the structure of the icy shell.	IO.1a	Identify and regionally characterize subsurface thermal or compositional horizons and structures related to the current or recent presence of water or brine. Obtain pairs of intersecting profiles of structures and subsurface dielectric horizons extending from 100 meters (desired) to 3 km (required) depth at 10-meter vertical resolution	Ice Penetrating Radar (IPR), (e.g., 60 MHz with 10-MHz bandwidth) with altimeter mode	(1) Acquire profiles through globally distributed regions: 6 equatorial panels (±30 deg Lat) and 4 panels at each pole (±60 deg in Lat) - total of 14 panels; (2) Require low-altitude flyby along a groundtrack achieving 800 km segments within each panel at altitude < 400 km at < 6 km/s. Two 800 km groundtrack segments in each sub-jovian panel and at least three 800 km groundtracks in each anti-jovian panel. Each groundtrack shall also intersect another groundtrack (intersection may be outside the panel of interest); a single radar pass of sufficient length and geometry may satisfy groundtrack and intersection requirements in adjacent panels; Floor: (1) & (2) satisfied in any 8 of the 14 panels including both anti- and sub-jovian equatorial panels; Baseline: (1) & (2) satisfied in any 11 of the 14 panels; one groundtrack intersection within each panel; (3) Groundtrack begins below ~1000 km altitude; (4) Acquire an altimetric profile during the radar groundtrack with a relative height accuracy of 15 m.	**Objective:** Updated and revise text so that it captures the original intent with more fluid wording, as requested by the Project Scientist. **Measurement:** Penetration from the surface to at least 100 m (required) and ideally to 3 km (desired)--clarification based on discussion with requirements working group (Ivair Gontijo) and mission design group. **Mission constraints/requirements:** Clarification to indicate that the requirement is for **"any"** 8 of the14 panels for the floor and **"any"** 11 of the 14 panels for the baseline. Version 2.1 (1) Clarification from Don Blankenship, SDT Ice Shell group lead, in terms of desired and required measurements. Because of noise from the surface, "There is no expectation of imaging shallower than (100m)." The shallower the target the more surface interference with the horizon so O(100m) is very difficult to image." As such, "desired" and "required" for each depth is updated to emphasize the concentration on deeper sounding. (2) The requirement is to sound below 400-km. The statement "...with 25 to 100 km closest approach." has been deleted as it is not a radar requirement. (3) Clarified that there should be at least three ground tracks in **"each"** anti-jovian panel. (4) Deep sounding mode (9 MHz with 1-MHz bandwidth) deleted as this is a shallow sounding measurement **Version 2.2** **Mission constraints/requirements:** (1) Update to altimetric profile height accuracy provided by Don Blankenship of the SDT; clarifies relative height accuracy rather than absolute height accuracy. SDT concurred change at 3 June 2014 SDT meeting.	✔		✔
				IO.1b	Acquire surface topography on the order of 250-m horizontal scale and better than or equal to 20-m vertical resolution and accuracy extending a lateral distance from the ground track sufficient to cover the surface projection of shallow radar target depths.	Topographical Imager (TI) and Ice Penetrating Radar (IPR), (e.g., -60 MHz with 10-MHz bandwidth), with altimeter mode	Stereo imaging: (1) The cross-track angular width (FOV) should be sufficient (a function of chosen flyby altitude and IPR penetration depth) to provide stereo imaging of the radar sounder groundtrack; (2) Require stereo imaging at incidence angles of ~20° to 80°. Desire imaging at solar incidence angles greater than 45°, preferably 70°. Ice Penetrating Radar with altimeter mode: (3) Acquire tracks of ~800 km in length co-located with a nadir-pointed altimetric profile with a relative height accuracy of 15 m.	**Measurement:** Use set of equations provided by Wes Patterson to calculate image swath width for stereo--based on discussion with Don Blankenship --Evaluate equality, (1) $t=h/c + dn/c$ and (2) $t=(h^2+(w/2)^2)^{1/2}/c$ where w is the cross-track width, h is spacecraft altitude, d is the RS penetration depth, n is the index of refraction for ice (~1.78), and c is the speed of light. --By setting equation (1) equal to equation (2), solve for w to derive an expression for cross-track width: $w=(8hdn + 4(dn)^2)^{1/2}$ Version 2.1 (1) Deep sounding mode (9 MHz with 1-MHz bandwidth) deleted as this is a shallow sounding measurement; (2) Measurement clarification regarding required width of Topographical Imager swath width on the surface. Clarification provided by Don Blankenship, SDT Ice Shell group lead. **Version 2.2** **Mission constraints/requirements:** (1) Update to altimetric profile height accuracy provided by Don Blankenship of the SDT; clarifies relative height accuracy rather than absolute height accuracy. SDT concurred change at 3 June 2014 SDT meeting.	✔		✔
		IO.2	Determine Europa's magnetic induction response to estimate ocean salinity and thickness	IO.2a	Measure three-axis magnetic field components at 8 vectors/s, and a sensitivity of 0.1 nT, to determine induction responses to imposed signals. Determine the Jupiter and induced Europa amplitudes to 1 nT accuracy.	Magnetometer (MAG)	(1) Low-altitude flybys, less than a satellite radius, distributed across a range of orbital phases (true anomaly) and at a variety of Jovian System III longitudes. Sampling of true anomaly and System III longitude need to be independent of each other; (2) Acquire high rate data (8 vectors/second) within +/- 18 Europa radii; for the remainder of the orbit acquire lower rate samples (1 vector/second) to characterize the background magnetic field environment; (3) Near continuous sampling of the induced field at times which allow adequate separation of the amplitudes at the two dominant contributing periods, which are the 85.2 hour orbital period of Europa, and the 11.2 hour period of Jupiter's rotation, as seen at Europa's position. (4) MAG boom deployment and stability accuracy of 0.75° (3-sigma). (5) MAG boom absolute pointing knowledge accuracy to 0.1° within 2 Europa radii, which is achieved with an knowledge accuracy of 1° and the use of regular in-flight MAG calibration rolls.	**Mission constraints/requirements:** (1) Define "variety" to be better than 30 degrees each of true anomaly and System III longitude--based on discussion and comments from the mission design team, the Project Scientist, and the SDT geophysics group lead, Bruce Bills. (2) The meaning of +/- 2 hours of encounter in time now expressed in terms of a distance, +/- 18 Europa radii--based on discussion comments from mission design team. Magnetometer changes: Input from the Project Scientist based on past SDT conclusions and the SDT geophysics group lead, Bruce Bills. Version 2.1 (1) Restores original SDT wording "distributed across a range of orbital phases (true anomaly) and at a variety of Jovian System III longitudes." Change back to original wording after discussion with the Project Scientist and the Project Science Team. (2) Clarification that the magnetic field needs to be sampled near continuously.	✔	✔	
				IO.2b	Characterize the local plasma density (electron and ion densities up to 10^6 cm^{-3}), temperature (in the range of 0.01 to a few eV) and flow (ion speed in the range 1-200 km/s) to constrain (in conjunction with modeling) the contribution from currents not related to the surface and ocean.	Langmuir Probe (LP)	(1) Low-altitude flybys less than a satellite radius, distributed across a range of orbital phases (true anomaly) and at a variety of Jovian System III longitudes. Sampling of true anomaly and System III longitude need to be independent of each other; (2) Simultaneous acquisition of electron and ion currents (operation in "sweep" mode); (3) 4π steradian coverage; (4) A variety of dayside hemisphere flybys spanning noon to dusk (or dawn) of Europa local time; (5) Acquire high rate data (256 discrete current voltage measurements, "sweep" every second) within +/- 18 Europa radii; for the remainder of the orbit acquire lower rate samples (256 current measurement "sweep" every 6 to 60 seconds) to characterize the background plasma environment.	**Mission constraints/requirements:** Define "variety" to be better than 30 degrees each of true anomaly and System III longitude--based on discussion comments from mission design team and the SDT geophysics group, lead Bruce Bills.. (2) The meaning of +/- 2 hours of encounter in time now expressed in terms of a distance such as +/- 18 Europa radii--based on discussion comments from mission design team. (3) Clarify that current voltage is broken down into 256 different measurements--based on discussion comments from mission design team. Version 2.1 (1) Restores original SDT wording "distributed across a range of orbital phases (true anomaly) and at a variety of Jovian System III longitudes." Change back to original wording after discussion with the Project Scientist and the Project Science Team.	✔		
				IO.2c	Determine electric field components (near DC to 3 MHz), and measure electron and ion density (up to 10^6 cm^{-3}), as well as electron temperature (in the range of 0.01 to a few eV), for local conductivity and electrical currents determination.	Langmuir Probe (LP)	(1) Low-altitude flybys less than a satellite radius, distributed across a range of orbital phases (true anomaly) and at a variety of Jovian System III longitudes. Sampling of true anomaly and System III longitude need to be independent of each other; (2) Simultaneous acquisition of electron and ion currents (operation in "sweep" mode); (3) 4π steradian coverage; (4) A variety of dayside hemisphere flybys spanning noon to dusk (or dawn) of Europa local time; (5) Acquire high rate data (1 spectrum - quasi-DC to 3 MHz - per second) within +/- 18 Europa radii; for the remainder of the orbit acquire lower rate samples (1 spectrum - quasi-DC to 3 MHz - every 6 to 30 seconds) to characterize the background electric field environment.	**Mission constraints/requirements:** Define "variety" to be better than 30 degrees each of true anomaly and System III longitude--based on discussion comments from mission design team and the SDT geophysics group lead, Bruce Bills.. (2) The meaning of +/- 2 hours of encounter in time now expressed in terms of a distance, +/- 18 Europa radii--based on discussion comments from mission design team. Version 2.1 (1) Restores original SDT wording "distributed across a range of orbital phases (true anomaly) and at a variety of Jovian System III longitudes." Change back to original wording after discussion with the Project Scientist and within the Project Science Team.	✔		
		IO.3	Search for an ice-ocean interface.	IO.3a	Identify deep thermal, compositional, or structural horizons by obtaining globally distributed regional profiles of subsurface dielectric horizons and structures extending 1 km (required) to 30 km (desired) depth from the surface at 100-m vertical resolution	Ice Penetrating Radar (IPR), (e.g., 9 MHz with 1-MHz bandwidth) with altimeter mode and Topographical Imager (TI)	(1) Acquire profiles through globally distributed regions: 6 equatorial panels (±30 deg Lat) and 4 panels at each pole (±60 deg in Lat) - total of 14 panels; (2) Low-altitude flyby along a groundtrack achieving ~1600 km segments within each panel at altitude <1000 km at < 6 km/s. Each groundtrack shall also intersect another groundtrack (intersection may be outside the panel of interest); a single radar pass of sufficient length and geometry may satisfy groundtrack and intersection requirements in adjacent panels; Required: (1) & (2) satisfied in any 8 of the 14 panels including both anti- and sub- jovian equatorial panels; Desired: (1) & (2) satisfied in any 11 of the 14 panels; one groundtrack intersection within each panel; (3) Groundtrack begins below ~1000 km altitude; (4) Acquire an altimetric profile during the profiling groundtrack with a relative height accuracy of 15 m.	**Measurement:** Penetration from the surface to at least 1 km (required) and ideally to 30 km (desired)--clarification from discussion with requirements working group (Ivair Gontijo) and mission design group. **Mission constraints/requirements:** Clarification to indicate that the requirement is for **"any"** 8 of the 14 panels for the floor and **"any"** 11 of the14 panels for the baseline. Version 2.1 (1) The requirement is to sound below 400-km. The statement "...with 25 to 100 km closest approach." has been deleted as it is not a radar requirement. (2) Shallow sounding mode (60 MHz with 10-MHz bandwidth) deleted as this is a deep sounding measurement **Version 2.2** **Mission constraints/requirements:** (1) Update to altimetric profile height accuracy provided by Don Blankenship of the SDT; clarifies relative height accuracy rather than absolute height accuracy. SDT concurred change at 3 June 2014 SDT meeting.	✔		✔
				IO.3b	Topography on the order of 250-m horizontal scale and better than or equal to 20-m vertical resolution and accuracy extending a lateral distance from the ground track sufficient to cover the projection of shallow radar target depths.	Topographical Imager (TI) and Ice Penetrating Radar (IPR), (e.g., 9 MHz with 1-MHz bandwidth) with altimeter mode	Stereo imaging: (1) The cross-track angular width (FOV) should be sufficient (a function of chosen flyby altitude and IPR penetration depth) to provide stereo imaging of the radar sounder groundtrack; (2) Require stereo imaging at incidence angles of ~20° to 80° (baseline range). Desire imaging at solar incidence angles greater than 45°, preferably 70°. Ice Penetrating Radar with altimeter mode: (3) Acquire tracks of ~1600 km in length co-located with a nadir-pointed altimetric profile with a relative height accuracy of 15 m.	**Measurement:** ~~Use set of equations provided by Wes Patterson to calculate image swath width for stereo--based on discussion with Don Blankenship~~ ~~--Evaluate equality, (1) t=h/c + dn/c and (2) t=(h²+(w/2)²)^1/2/c where w is the cross-track width, h is spacecraft altitude, d is the RS penetration depth, n is the index of refraction for ice (~1.78), and c is the speed of light.~~ ~~--By setting equation (1) equal to equation (2), solve for w to derive an expression for cross-track width:~~ ~~w=(8hdn + 4(dn)²)^1/2~~ **Mission constraints/requirements:** (1) Clarification of the baseline range; (2) "Desire" is the preferred range of incidence angles--based on discussion with the mission design team. Also based on discussion with SDT Geology group lead Jeff Moore. Version 2.1 (1) Shallow sounding mode (60 MHz with 10-MHz bandwidth) deleted as this is a deep sounding measurement (2) Measurement clarification regarding required width of Topographical Imager swath width on the surface. Clarification provided by Don Blankenship, SDT Ice Shell group lead. **Version 2.2** **Mission constraints/requirements:** (1) Update to altimetric profile height accuracy provided by Don Blankenship of the SDT; clarifies relative height accuracy rather than absolute height accuracy. SDT concurred change at 3 June 2014 SDT meeting.	✔		✔
				IO.3c	Near global-scale monoscopic imaging at better than or equal to 1 km/pixel inbound and outbound on each flyby sufficient to cover surface projections of the deep radar target depths.	Topographical Imager (TI)	(1) Global-scale (monoscopic) coverage of greater than or equal to 70% of Europa spatially coincident with the radar swath. (2) Make observations when the solar phase angle is ≤135 degrees.	Version 2.1 (1) As per Don Blankenship, SDT Ice Shell group lead, for the deep ocean search, the TI swath requirement does not always apply. Instead, monoscopic image coverage is needed at a resolution of better than or equal 1 km/pixel resolution, spatially coincident with the radar swath. (2) Measurement clarification regarding required width of Topographical Imager swath width on the surface. Clarification provided by Don Blankenship, SDT Ice Shell group lead.	✔		✔
				IO.3d	Measure three-axis magnetic field components at 8 vectors/s, and a sensitivity of 0.1 nT, to determine induction responses to imposed signals. Determine the Jupiter and induced Europa amplitudes to 1 nT accuracy.	Magnetometer (MAG)	(1) Low-altitude flybys, less than a satellite radius, distributed across a range of orbital phases (true anomaly) and at a variety of Jovian System III longitudes. Sampling of true anomaly and System III longitude need to be independent of each other; (2) Acquire high rate data (8 vectors/second) within +/- 18 Europa radii; for the remainder of the orbit acquire lower rate samples (1 vector/second) to characterize the background magnetic field environment; (3) Near continuous sampling of the induced field at times which allow adequate separation of the amplitudes at the two dominant contributing periods, which are the 85.2 hour orbital period of Europa, and the 11.2 hour period of Jupiter's rotation, as seen at Europa's position. (4) MAG boom deployment and stability accuracy of 0.75° (3-sigma). (5) MAG boom absolute pointing knowledge accuracy to 0.1° within 2 Europa radii, which is achieved with an knowledge accuracy of 1° and the use of regular in-flight MAG calibration rolls.	Mission constraints/requirements: (1) Define "variety" to be better than 30 degrees each of true anomaly and System III longitude--based on discussion and comments from the mission design team, the Project Scientist, and the SDT geophysics group lead, Bruce Bills. (2) The meaning of +/- 2 hours of encounter in time now expressed in terms of a distance, +/- 18 Europa radii--based on discussion comments from mission design team. Magnetometer changes: Input from the Project Scientist based on past SDT conclusions and the SDT geophysics group lead, Bruce Bills. Version 2.1 (1) Restores original SDT wording "distributed across a range of orbital phases (true anomaly) and at a variety of Jovian System III longitudes." Change back to original wording after discussion with the Project Scientist and the Project Science Team. (2) Clarification that the magnetic field needs to be sampled near continuously. **Version 2.2** Addition of magnetometer measurement as requested by SDT Ocean and Ice Shell group member Jack Connerney as this method should be important in constraining the location of the ocean-ice shell interface. Addition concurred by full SDT at 3 June 2014 meeting.	✔	✔	
				IO.3e	Characterize the local plasma density (electron and ion densities up to 10^6 cm^{-3}), temperature (in the range of 0.01 to a few eV) and flow (ion speed in the range 1-200 km/s) to constrain (in conjunction with modeling) the contribution from currents not related to the surface and ocean.	Langmuir Probe (LP)	(1) Low-altitude flybys less than a satellite radius, distributed across a range of orbital phases (true anomaly) and at a variety of Jovian System III longitudes. Sampling of true anomaly and System III longitude need to be independent of each other; (2) Simultaneous acquisition of electron and ion currents (operation in "sweep" mode); (3) 4π steradian coverage; (4) A variety of dayside hemisphere flybys spanning noon to dusk (or dawn) of Europa local time; (5) Acquire high rate data (256 discrete current voltage measurements, "sweep" every second) within +/- 18 Europa radii; for the remainder of the orbit acquire lower rate samples (256 current measurement "sweep" every 6 to 60 seconds) to characterize the background plasma environment.	**Mission constraints/requirements:** Define "variety" to be better than 30 degrees each of true anomaly and System III longitude--based on discussion comments from mission design team and the SDT geophysics group, lead Bruce Bills.. (2) The meaning of +/- 2 hours of encounter in time now expressed in terms of a distance such as +/- 18 Europa radii--based on discussion comments from mission design team. (3) Clarify that current voltage is broken down into 256 different measurements--based on discussion comments from mission design team. Version 2.1 (1) Restores original SDT wording "distributed across a range of orbital phases (true anomaly) and at a variety of Jovian System III longitudes." Change back to original wording after discussion with the Project Scientist and the Project Science Team. **Version 2.2** Addition of magnetometer measurement as requested by SDT Ocean and Ice Shell group member Jack Connerney as this method should be important in constraining the location of the ocean-ice shell interface. Addition concurred by full SDT at 3 June 2014 meeting.	✔		
				IO.3f	Determine electric field components (near DC to 3 MHz), and measure electron and ion density (up to 10^6 cm^{-3}), as well as electron temperature (in the range of 0.01 to a few eV), for local conductivity and electrical currents determination.	Langmuir Probe (LP)	(1) Low-altitude flybys less than a satellite radius, distributed across a range of orbital phases (true anomaly) and at a variety of Jovian System III longitudes. Sampling of true anomaly and System III longitude need to be independent of each other; (2) Simultaneous acquisition of electron and ion currents (operation in "sweep" mode); (3) 4π steradian coverage; (4) A variety of dayside hemisphere flybys spanning noon to dusk (or dawn) of Europa local time; (5) Acquire high rate data (1 spectrum - quasi-DC to 3 MHz - per second) within +/- 18 Europa radii; for the remainder of the orbit acquire lower rate samples (1 spectrum - quasi-DC to 3 MHz - every 6 to 30 seconds) to characterize the background electric field environment.	**Mission constraints/requirements:** Define "variety" to be better than 30 degrees each of true anomaly and System III longitude--based on discussion comments from mission design team and the SDT geophysics group lead, Bruce Bills.. (2) The meaning of +/- 2 hours of encounter in time now expressed in terms of a distance, +/- 18 Europa radii--based on discussion comments from mission design team. Version 2.1 (1) Restores original SDT wording "distributed across a range of orbital phases (true anomaly) and at a variety of Jovian System III longitudes." Change back to original wording after discussion with the Project Scientist and within the Project Science Team. **Version 2.2** Addition of magnetometer measurement as requested by SDT Ocean and Ice Shell group member Jack Connerney as this method should be important in constraining the location of the ocean-ice shell interface. Addition concurred by full SDT at 3 June 2014 meeting.	✔		
		IO.4	Correlate surface features and subsurface structure to investigate processes governing material exchange among the ocean, ice shell, surface, and atmosphere.	IO.4a	Identify and regionally characterize subsurface dielectric horizons and structures extending 1 km (required) to 30 km (desired) depth from the surface at 100-m vertical resolution and extending from 100 meters (desired) to 3 km (required) depth at 10-m vertical resolution, by obtaining intersecting subsurface profiles distributed over a variety of surface features.	Ice Penetrating Radar (IPR), dual-frequency (e.g., 9 MHz with 1-MHz bandwidth, and 60 MHz with 10-MHz bandwidth), with altimeter mode	(1) Acquire profiles through globally distributed regions: 6 equatorial panels (±30 deg Lat) and 4 panels at each pole (±60 deg in Lat) - total of 14 panels; (2) Require low-altitude flyby along a groundtrack achieving 800 km segments within each panel at altitude <400 km at < 6 km/s. Two 800 km groundtrack segments in each sub-jovian panel and at least three 800 km groundtracks in each anti-jovian panel. Each groundtrack shall also intersect another groundtrack (intersection may be outside the panel of interest); a single radar pass of sufficient length and geometry may satisfy groundtrack and intersection requirements in adjacent panels; Required: (1) & (2) satisfied in any 8 of the 14 panels including both anti- and sub- jovian equatorial panels; Desired: (1) & (2) satisfied in any 11 of the 14 panels; one groundtrack intersection within each panel; (3) Radar groundtrack begins below ~1000 km altitude; (4) Acquire an altimetric profile during the radar groundtrack with a relative height accuracy of 15 m.	**Measurement:** (1) Penetration from the surface to at least 100 m (required) and ideally to 3 km (desired)--clarification from discussion with requirements working group (Ivair Gontijo) and mission design group. (2) Penetration from the surface to at least 1 km (required) and ideally to 30 km (desired)--clarification from discussion with requirements working group (Ivair Gontijo) and mission design group. **Mission constraints/requirements:** Clarification to indicate that the requirement is for **"any"** 8 of the 14 panels for the floor and **"any"** 11 of the 14 panels for the baseline. Version 2.1 (1) Clarification from Don Blankenship, SDT Ice Shell group lead, in terms of desired and required measurements. Because of noise from the surface, "There is no expectation of imaging shallower than (100m)." The shallower the target the more surface interference with the horizon so O(100m) is very difficult to image." As such, "desired" and "required" for each depth is updated to emphasize the concentration on deeper sounding. (2) The requirement is to sound below 400-km. The statement "...with 25 to 100 km closest approach." has been deleted as it is not a radar requirement. (3) Clarified that there should be at least three ground tracks in "each" anti-jovian panel. **Version 2.2** **Investigation:** (1) Investigation updated by the SDT at February 2014 SDT meeting based on recent announcement of the discovery of potential Europa plumes. **Mission constraints/requirements:** (2) Update to altimetric profile height accuracy provided by Don Blankenship of the SDT; clarifies relative height accuracy rather than absolute height accuracy. SDT concurred change at 3 June 2014 SDT meeting.	✔		✔
				IO.4b	Measure surface reflectance from 850 to 5000 nm with 10 nm resolution below 2500 nm and 20 nm from 2500 to 5000 nm. Acquire targeted observations of ~100 representative landforms at better than or equal to 300 m/pixel sampling over a wide range of latitudes and longitudes.	ShortWave InfraRed Spectrometer (SWIRS)	(1) Ability to target specific geologic locations that are globally distributed: 6 equatorial panels (±30 deg Lat) and 4 panels at each pole (±60 deg in Lat) - total of 14 panels; Floor: Sampling in any 8 of the 14 panels; Baseline: Sampling in any 11 of the 14 panels; (2) Require low-altitude flyby along a groundtrack within each panel at altitude <1000 km at ≤ 6 km/s with 25 to 100 km closest approach; (3) Observations on the leading and trailing hemisphere are required in addition to at least one at high latitude (poleward of 45°); (4) Require solar incidence angles at the equator of less than 45° (local true solar time between 9:00 to 15:00); (5) Ability of spacecraft to smoothly scan over the surface--the spacecraft would be stable and quiet (e.g. no articulations or momentum dumping during observations)--to build up spectral image cube with a spacecraft stability requirement of less than 1/2 IFOV over the integration time.	**Measurement:** The expectation is that many of the 100 landforms would be selected prior to JOI (the limitations of the Galileo data set will drive the number selected prior to JOI)--based on discussion with Mission design team. **Mission constraints/requirements:** (1) Clarification to indicate that the requirement is for **"any"** 8 of the 14 panels for the floor and **"any"** 11 of the 14 panels for the baseline. (2) The "ability of spacecraft to smoothly scan over the surface" implies that there would most likely be articulation in the instrument and that the spacecraft would be stable and quiet (e.g. no other articulations or momentum dumping during observations)--clarification based on discussion with the mission design group.--This statement was inadvertently omitted from Version 2.0 Version 2.1 (1) Clarification from Diana Blaney that the resolution needs to be "better than or equal to." (2) High latitude defined as greater than 45° (either north or south). Remove the word "pass" as it is ambiguous.	✔	✔	✔
				IO.4c	Topography on the order of 250-m horizontal scale and better than or equal to 20-m vertical resolution and accuracy extending a lateral distance from the ground track sufficient to cover the surface projection of shallow radar target depths.	Topographical Imager (TI) an Ice Penetrating Radar (IPR), dual-frequency (e.g., 9 MHz with 1-MHz bandwidth, and 60 MHz with 10-MHz bandwidth), with altimeter mode	Stereo imaging: (1) The cross-track angular width (FOV) should be sufficient (a function of chosen flyby altitude and IPR penetration depth) to provide stereo imaging of the radar sounder groundtrack; (2) Require stereo imaging at incidence angles of ~20° to 80° (baseline range). Desire imaging at solar incidence angles greater than 45°, preferably 70°. Ice Penetrating Radar with altimeter mode: (3) Acquire tracks of ~800 km in length co-located with a nadir-pointed altimetric profile with a relative height accuracy of 15 m.	**Measurement:** Use set of equations provided by Wes Patterson to calculate image swath width for stereo--based on discussion with Don Blankenship --Evaluate equality, (1) $t=h/c + dn/c$ and (2) $t=(h^2+(w/2)^2)^{1/2}/c$ where w is the cross-track width, h is spacecraft altitude, d is the RS penetration depth, n is the index of refraction for ice (~1.78), and c is the speed of light. --By setting equation (1) equal to equation (2), solve for w to derive an expression for cross-track width: $w=(8hdn + 4(dn)^2)^{1/2}$ **Mission constraints/requirements:** (1) Clarification of the baseline range; (2) "Desire" is the preferred range of incidence angles--based on discussion with the mission design team. (3) Added wording to clarify that an accuracy of "better than or equal to" 10 m is required.(2) Measurement clarification regarding required width of Topographical Imager swath width on the surface. Clarification provided by Don Blankenship, SDT Ice Shell group lead. Version 2.1 (1) Measurement clarification regarding required width of Topographical Imager swath width on the surface. Clarification provided by Don Blankenship, SDT Ice Shell group lead. **Version 2.2** **Mission constraints/requirements:** (1) Update to altimetric profile height accuracy provided by Don Blankenship of the SDT; clarifies relative height accuracy rather than absolute height accuracy. SDT concurred change at 3 June 2014 SDT meeting.	✔		✔
		IO.5	Determine the amplitude and phase of gravitational tides.	IO.5a	Measure degree-two time-dependent gravity field, to recover k_2 amplitude at Europa's orbital frequency to 0.05 absolute accuracy	Radio subsystem (RS)	(1) Requires low-altitude flybys (<100 km) distributed between near Europa's periapsis and near Europa's apoapsis and at 2 different locations; (2) Range-rate measurements with an accuracy better than 0.1 mm/s at 60 sec integration time to determine spacecraft orbit to better than 1-meter (rms) in radial direction; (3) Requires continuous Doppler data tracking +/-18 Europa radii around Europa closest approach; (4) Flybys should occur far from solar conjunction to minimize the effects of plasma noise; (5) The spacecraft must not be occulted by Europa during +/-18 Europa radii around closest approach. (6) Baseline: measurement of the tidal gravity Love number (k_2) to an absolute accuracy goal of 0.05; Floor: measurement of the tidal gravity Love number (k_2) to an absolute accuracy goal of 0.06.	**Mission constraints/requirements:** (1) Add specificity that distribution of true anomalies should better than every 30 degrees; (2) low altitude flybys needed to determine static gravity field to degree 10 which is a correction factor in determining k_2--based on discussion with the payload team and the SDT geophysics group lead, Bruce Bills. The meaning of +/- 2 hours of encounter in time now expressed in terms of a distance, +/-18 Europa radii--based on discussion comments from mission design team. Version 2.1 (1) Restores original SDT wording "distributed between near Europa's periapsis and near Europa's apoapsis and at 2 different locations." Change back to original wording after discussion with the Project Scientist and within the Project Science Team. **Version 2.2** **Mission constraints/requirements:** (1) Modification of "Mission constraints/requirements" to include baseline and floor for gravity Love number. Input provided by Ice Shell and Ocean group led by Bruce Bills with concurrence by the SDT.	✔		
		IO.6	Characterize regional and global heat flow variations.	IO.6a	Identify and map subsurface thermal horizons, by obtaining profiles of subsurface dielectric horizons extending 1 km (required) to 30 km (desired) depth from the surface at 10-100-m vertical resolution.	Ice Penetrating Radar (IPR), (e.g., 9 MHz with 1-MHz bandwidth) with altimeter mode and Topographical Imager (TI)	Ice Penetrating Radar: (1) Acquire globally distributed regions: 6 equatorial panels (±30 deg Lat) and 4 panels at each pole (±60 deg in Lat) - total of 14 panels. (2) Require low-altitude flyby along a groundtrack achieving 800 km segments within each panel at altitude <400 km at < 6 km/s. Two 800 km groundtrack segments in each sub-jovian panel and at least three 800 km groundtracks in each anti-jovian panel. Each groundtrack shall also intersect another groundtrack (intersection may be outside the panel of interest); a single radar pass of sufficient length and geometry may satisfy groundtrack and intersection requirements in adjacent panels; Required: (1) & (2) satisfied in any 8 of the 14 panels including both anti- and sub- jovian equatorial panels; Desired: (1) & (2) satisfied in any 11 of the 14 panels; one groundtrack intersection within each panel; (3) Radar groundtrack begins below 1000 km altitude with altimetry mode. (4) Acquire an altimetric profile during the radar groundtrack with a relative height accuracy of 15 m. Stereo imaging: (5) The cross-track angular width (FOV) should be sufficient (a function of chosen flyby altitude and IPR penetration depth) to provide stereo imaging of the radar sounder groundtrack; (6) Require stereo imaging at incidence angles of ~20° to 80°. Desire imaging at solar incidence angles greater than 45°, preferably 70°.	**Measurement:** Penetration from the surface to at least 1 km (floor) and ideally to 30 km (baseline)--clarification from discussion with requirements working group (Ivair Gontijo) and mission design group. **Mission constraints/requirements:** Clarification to indicate that the requirement is for **"any"** 8 of the14 panels for the floor and **"any"** 11 of the 14 panels for the baseline. Version 2.1 (1) The requirement is to sound below 400-km. The statement "...with 25 to 100 km closest approach." has been deleted as it is not a radar requirement. (2) Clarified that there should be at least three ground tracks in **"each"** anti-jovian panel. (3) Shallow sounding mode (60 MHz with 10-MHz bandwidth) deleted as this is a deep sounding measurement **Version 2.2** **Mission constraints/requirements:** (1) Update to altimetric profile height accuracy provided by Don Blankenship of the SDT; clarifies relative height accuracy rather than absolute height accuracy. SDT concurred change at 3 June 2014 SDT meeting.	✔		✔
	C. Composition Understand the habitability of Europa's ocean through composition and chemistry.	C.1	Characterize the composition and chemistry of the Europa ocean as expressed on the surface and in the atmosphere including potential plumes	C.1a	Measure surface reflectance from 850 to 5000 nm with 10 nm resolution below 2500 nm and 20 nm from 2500 to 5000 nm. Acquire targeted observations of ~100 representative landforms at regional-scales (better than or equal to 300 m/pixel sampling) over a wide range of latitudes and longitudes.	ShortWave InfraRed Spectrometer (SWIRS)	(1) Ability to target specific geologic locations that are globally distributed: 6 equatorial panels (±30 deg Lat) and 4 panels at each pole (±60 deg in Lat) - total of 14 panels; Required: Sampling in any 8 of the 14 panels; Desired: Sampling in any 11 of the 14 panels; (2) Require low-altitude flyby along a groundtrack within each panel at altitude <1000 km at ≤ 6 km/s; (3) Observations on the leading and trailing hemisphere are required in addition to at least one at high latitude (poleward of 45°); (4) Require solar incidence angles at the equator of less than 45° (local true solar time between 9:00 to 15:00); (5) Ability of spacecraft to smoothly scan over the surface to build up spectral image cube with a spacecraft stability requirement of less than 1/2 IFOV over the integration time.	**Measurement:** The expectation is that many of the 100 landforms would be selected prior to JOI (the limitations of the Galileo data set will drive the number selected prior to JOI)--based on discussion with Mission design team. **Mission constraints/requirements:** (1) Clarification to indicate that the requirement is for **"any"** 8 of the 14 panels for the floor and **"any"** 11 of the 14 panels for the baseline. (2) The "ability of spacecraft to smoothly scan over the surface" implies that there would most likely be articulation in the instrument and that the spacecraft would be stable and quiet (e.g. no other articulations or momentum dumping during observations)--clarification based on discussion with the mission design group.--This statement was inadvertently omitted from Version 2.0 Version 2.1 (1) Clarification from Diana Blaney that the resolution needs to be "better than or equal to." (2) High latitude defined as greater than 45° (either north or south). Remove the word "pass" as it is ambiguous. (3) The requirement is to acquire data below 1000-km. The statement "...with 25 to 100 km closest approach." has been deleted as it is not a SWIRS requirement. **Version 2.2** **Investigation:** (1) Investigation updated by the SDT at February 2014 SDT meeting based on recent announcement of the discovery of potential Europa plumes.	✔	✔	
				C.1b	Characterize the composition of Europa's atmosphere and possible plume material, with an emphasis on identifying compounds of astrobiological relevance (e.g. aliphatic and aromatic organics, including hydrocarbons and any nitrogen, phosphorous, sulfur-bearing organics, and key inorganic species such as Na, K, CO_2 and SO_2). Provide better than unit-mass resolution to compounds over the entire molecular weight range to at least 300 Da, with a concentration range of at least 10^5 in any plume materials.	Neutral Mass Spectrometer (NMS)	(1) Require flyby velocity of < 7 km/s (required--baseline); (2) Flyby altitudes of < 200 km (required) with lower altitude passes, as low as 25 km, desired. (3) The NMS should be capable of making measurements when oriented as much as 10° away from the spacecraft ram direction (expected when below 200-km altitude).	**Mission constraints/requirements:** (1) Clarification that the requirement is the baseline. (2) Delete "with slower speeds desirable" as it is not quantified or well justified--based on discussion with the mission design team. **Version 2.2** **Measurement:** (1) Updated Measurement provided by the SDT composition group chaired by Diana Blaney **Mission constraints/requirements:** (1) Addition of requirement regarding orientation of NMS during flyby based on Cassini INMS and discussion with the SDT composition group, Will Brinkerhoff, Steve Vance, and the Clipper Project Scientist. Concurred by the full SDT on 3 June 2014.	✔	✔	
		C.2	Determine the role of Jupiter's radiation environment in processing materials on Europa	C.2a	Measure surface reflectance from 850 to 5000 nm with 10 nm resolution n < 2500 nm and 20 nm from 2500 to 5000 nm. Targeted observations of ~100 representative landforms at regional-scales (better than or equal to 300 m/pixel sampling) over a wide range of latitudes and longitudes.	ShortWave InfraRed Spectrometer (SWIRS)	(1) Ability to target specific geologic locations that are globally distributed: 6 equatorial panels (±30 deg Lat) and 4 panels at each pole (±60 deg in Lat) - total of 14 panels; Required: Sampling in any 8 of the 14 panels; Desired: Sampling in any 11 of the 14 panels; (2) Require low-altitude flyby along a groundtrack within each panel at altitude <1000 km at ≤ 6 km/s; (3) Observations on the leading and trailing hemisphere are required in addition to at least one at high latitude (poleward of 45°); (4) Require solar incidence angles at the equator of less than 45° (local true solar time between 9:00 to 15:00); (5) Ability of spacecraft to smoothly scan over the surface to build up spectral image cube with a spacecraft stability requirement of less than 1/2 IFOV over the integration time.	**Measurement:** The expectation is that many of the 100 landforms would be selected prior to JOI (the limitations of the Galileo data set will drive the number selected prior to JOI)--based on discussion with Mission design team. **Mission constraints/requirements:** (1) Clarification to indicate that the requirement is for **"any"** 8 of the 14 panels for the floor and **"any"** 11 of the 14 panels for the baseline. (2) The "ability of spacecraft to smoothly scan over the surface" implies that there would most likely be articulation in the instrument and that the spacecraft would be stable and quiet (e.g. no other articulations or momentum dumping during observations)--clarification based on discussion with the mission design group.--This statement was inadvertently omitted from Version 2.0 Version 2.1 (1) Clarification from Diana Blaney that the resolution needs to be "better than or equal to." (2) High latitude defined as greater than 45° (either north or south). Remove the word "pass" as it is ambiguous. (3) The requirement is to acquire data below 1000-km. The statement "...with 25 to 100 km closest approach." has been deleted as it is not a SWIRS requirement.		✔	✔
				C.2b	Characterize the composition of Europa's atmosphere and possible plume material, with an emphasis on identifying compounds of astrobiological relevance (e.g. aliphatic and aromatic organics, including hydrocarbons and any nitrogen, phosphorous, sulfur-bearing organics, and key inorganic species such as Na, K, CO_2 and SO_2). Provide better than unit-mass resolution to compounds over the entire molecular weight range to at least 300 Da, with a concentration range of at least 10^5 in any plume materials.	Neutral Mass Spectrometer (NMS)	(1) Require flyby velocity of < 7 km/s (required--baseline); (2) Flyby altitudes of < 200 km (required) with lower altitude passes, as low as 25 km, desired. (3) The NMS should be capable of making measurements when oriented as much as 10° away from the spacecraft ram direction (expected when below 200-km altitude).	**Mission constraints/requirements:** (1) Clarification that the requirement is the baseline. (2) Delete "with slower speeds desirable" as it is not quantified or well justified--based on discussion with the mission design team. **Version 2.2** **Measurement:** (1) Updated Measurement provided by the SDT composition group chaired by Diana Blaney **Mission constraints/requirements:** (1) Addition of requirement regarding orientation of NMS during flyby based on Cassini INMS and discussion with the SDT composition group, Will Brinkerhoff, Steve Vance, and the Clipper Project Scientist. Concurred by the full SDT on 3 June 2014.		✔	✔
		C.3	Characterize the chemical and compositional pathways in Europa's ocean.	C.3a	Measure surface reflectance from 850 to 5000 nm with 10 nm resolution < 2500 nm and 20 nm from 2500 to 5000 nm. Targeted observations of ~100 representative landforms at better than or equal to 300 m/pixel sampling and global-scale coverage with a spatial sampling better than or equal to 10 km/pixel	ShortWave InfraRed Spectrometer (SWIRS)	(1) Ability to target specific geologic locations that are globally distributed: 6 equatorial panels (±30 deg Lat) and 4 panels at each pole (±60 deg in Lat) - total of 14 panels; Required: Sampling in any 8 of the 14 panels; Desired: Sampling in any 11 of the 14 panels; (2) Require low-altitude flyby along a groundtrack within each panel at altitude <1000 km at ≤ 6 km/s; (3) Observations on the leading and trailing hemisphere are required in addition to at least one at high latitude (poleward of 45°); (4) Require solar incidence angles at the equator of less than 45° (local true solar time between 9:00 to 15:00); (5) Ability of spacecraft to smoothly scan over the surface to build up spectral image cube with a spacecraft stability requirement of less than 1/2 IFOV over the integration time. (6) Global-scale coverage over 70% of the surface (baseline). Global-scale coverage of 50% of the surface with sampling required of the leading and trailing hemispheres, and at high and mid latitudes (floor).	**Measurement:** The expectation is that many of the 100 landforms would be selected prior to JOI (the limitations of the Galileo data set will drive the number selected prior to JOI)--based on discussion with Mission design team. **Mission constraints/requirements:** (1) Clarification to indicate that the requirement is for "any" 8 of the 14 panels for the floor and "any" 11 of the 14 panels for the baseline.--This statement was inadvertently omitted from Version 2.0 (2)Addition of percentage surface coverage based on discussion with the mission design team and discussion with SDT Geology group, led by Louise Prockter and Jeff Moore. (3) The "ability of spacecraft to smoothly scan over the surface" implies that there would most likely be articulation in the instrument and that the spacecraft would be stable and quiet (e.g. no other articulations or momentum dumping during observations)--clarification based on discussion with the mission design group.--This statement was inadvertently omitted from Version 2 Version 2.1 (1) Clarification from Diana Blaney that the resolution needs to be "better than or equal to." (2) High latitude defined as greater than 45° (either north or south). Remove the word "pass" as it is ambiguous. (3) The requirement is to acquire data below 1000-km. The statement "...with 25 to 100 km closest approach." has been deleted as it is not a SWIRS requirement. **Version 2.2** **Mission constraints/requirements:** (1) Modification of "Mission constraints/requirement" wording to add floor coverage. Changes supplied by the composition group led by Diana Blaney with concurrence by the SDT	✔	✔	
				C.3b	Characterize the composition of Europa's atmosphere and possible plume material, with an emphasis on identifying compounds of astrobiological relevance (e.g. aliphatic and aromatic organics, including hydrocarbons and any nitrogen, phosphorous, sulfur-bearing organics, and key inorganic species such as Na, K, CO_2 and SO_2). Provide better than unit-mass resolution to compounds over the entire molecular weight range to at least 300 Da, with a concentration range of at least 10^5 in any plume materials.	Neutral Mass Spectrometer (NMS)	(1) Require flyby velocity of < 7 km/s (required--baseline); (2) Flyby altitudes of < 200 km (required) with lower altitude passes, as low as 25 km, desired. (3) The NMS should be capable of making measurements when oriented as much as 10° away from the spacecraft ram direction (expected when below 200-km altitude).	**Mission constraints/requirements:** (1) Clarification that the requirement is the baseline. (2) Delete "with slower speeds desirable" as it is not quantified or well justified--based on discussion with the mission design team. **Version 2.2** **Measurement:** (1) Updated measurement provided by the SDT composition group chaired by Diana Blaney **Mission constraints/requirements:** (1) Addition of requirement regarding orientation of NMS during flyby based on Cassini INMS and discussion with the SDT composition group, Will Brinkerhoff, Steve Vance, and the Clipper Project Scientist. Concurred by the full SDT on 3 June 2014.	✔	✔	
				C.3c	Correlate surface composition with geologic features through mapping at resolution of better than or equal to 100-m/pixel for locations measured by spectroscopy with simultaneous nadir coverage at ranges below 400 km.	Topographical Imager (TI) (stereo)	(1) Require stereo imaging at incidence angles of ~20° to 80° (baseline range). Desire imaging at solar incidence angles greater than 45°, preferably 70°.	**Mission constraints/requirements:** (1) Clarification of the baseline range, (2) "Desire" is the preferred range of incidence angles--based on discussion with the mission design team. Version 2.1 Correction of typographical error in the investigation	✔	✔	
	G. Geology Understand the formation of surface features, including sites of recent or current activity, and characterize high science interest localities.	G.1	Determine sites of most recent geological activity, including potential plumes, and characterize localities of high science interest.	G.1a	Characterize selected targets at ~20–40 m/pixel and characterize their topography at better than 100 m horizontal scale and better than or equal to 10-meter vertical resolution and accuracy.	Topographical Imager (TI) (stereo)	(1) Require stereo imaging at incidence angles of ~20° to 80° (baseline range). Desire imaging at solar incidence angles greater than 45°, preferably 70°. (2) Targets will lie along the ground track, with many selected a prior to JOI	**Mission constraints/requirements:** (1) Clarification of the baseline range, (2) "Desire" is the preferred range of incidence angles--based on discussion with the mission design team. (3) Clarification that the targets will lie along the groundtrack (no slewing) and many will be selected prior to JOI. The spotty nature of higher resolution Galileo data will allow many, but not all, targets to be selected a priori--based on discussion with the mission design team **Version 2.2** **Investigation:** (1) Investigation updated by the SDT at February 2014 SDT meeting based on recent announcement of the discovery of potential Europa plumes.	✔		✔
				G.1b	Characterize the composition of Europa's atmosphere and possible plume material, with an emphasis on identifying compounds of astrobiological relevance (e.g. aliphatic and aromatic organics, including hydrocarbons and any nitrogen, phosphorous, sulfur-bearing organics, and key inorganic species such as Na, K, CO_2 and SO_2). Provide better than unit-mass resolution to compounds over the entire molecular weight range to at least 300 Da, with a concentration range of at least 10^5 in any plume materials.	Neutral Mass Spectrometer (NMS)	(1) Require flyby velocity of < 7 km/s (required); (2) Flyby altitudes of < 200 km (required--baseline) with lower altitude passes, as low as 25 km, desired. (3) The NMS should be capable of making measurements when oriented as much as 10° away from the spacecraft ram direction (expected when below 200-km altitude).	**Mission constraints/requirements:** (1) Clarification that the requirement is the baseline. Version 2.1 (1) Delete "with slower speeds desirable" as it is not quantified or well justified--based on discussion with the mission design team. This was deleted from the Composition constraints/requirements in Version 2.0 but was missed here. This corrects the omission **Version 2.2** **Measurement:** (1) Updated Measurement provided by the SDT composition group chaired by Diana Blaney **Mission constraints/requirements:** (1) Addition of requirement regarding orientation of NMS during flyby based on Cassini INMS and discussion with the SDT composition group, Will Brinkerhoff, Steve Vance, and the Clipper Project Scientist. Concurred by the full SDT on 3 June 2014.	✔	✔	
				G.1c	Search for and characterize the structure of any potential plumes	Topographical Imager (TI)	(1) Require monochromatic imaging of the bright limb of Europa including background sky at a resolution of 2 to 10 km/pixel and less than or equal 15 degrees of longitude on the bright limb, at a range of orbital true anomalies. (2) Make observations when the solar phase angle is greater than or equal to 135 degrees.	**Version 2.2** **Measurement:** (1) Addition of plume search and characterization measurement based on overall SDT discussion from the 4 February 2014 SDT meeting	✔		✔
				G.1d	Characterize the surface and subsurface structure of sites associated with potential plumes	Ice Penetrating Radar (IPR), (e.g., 60 MHz with 10-MHz bandwidth) with altimeter mode	(1) Acquire profiles through globally distributed regions: 6 equatorial panels (±30 deg Lat) and 4 panels at each pole (±60 deg in Lat) - total of 14 panels; (2) Require low-altitude flyby along a groundtrack achieving 800 km segments within each panel at altitude < 400 km at < 6 km/s. Two 800 km groundtrack segments in each sub-jovian panel and at least three 800 km groundtracks in each anti-jovian panel. Each groundtrack shall also intersect another groundtrack (intersection may be outside the panel of interest); a single radar pass of sufficient length and geometry may satisfy groundtrack and intersection requirements in adjacent panels; Floor: (1) & (2) satisfied in any 8 of the 14 panels including both anti- and sub-jovian equatorial panels; Baseline: (1) & (2) satisfied in any 11 of the 14 panels; one groundtrack intersection within each panel; (3) Groundtrack begins below ~1000 km altitude; (4) Acquire an altimetric profile during the radar groundtrack with a relative height accuracy of 15 m.	**Version 2.2** **Measurement:** (1) Addition of measurement to characterize the subsurface of sites associated with potential plumes based on overall SDT discussion from the 4 February 2014 SDT meeting **Mission constraints/requirements:** (2) Update to altimetric profile height accuracy provided by Don Blankenship of the SDT; clarifies relative height accuracy rather than absolute height accuracy. SDT concurred change at 3 June 2014 SDT meeting.	✔		✔
		G.2	Determine the formation and three-dimensional characteristics of magmatic, tectonic, and impact landforms.	G.2a	Near global-scale monoscopic imaging at better than or equal to 1 km/pixel inbound and outbound on each flyby.	Topographical Imager (TI)	(1) Baseline: global-scale coverage of greater than or equal to 70% of Europa; Floor: global-scale coverage of greater than or equal to 50% of Europa; (2) Make observations when the solar phase angle is ≤135 degrees.	Version 2.1 The statement, "obtained with no (or limited) spacecraft slewing when the resolution is between 0.5-1.0 km/pixel" is an implementation method rather than a science requirement so has been deleted. **Version 2.2** **Measurement:** (1) Changed ≥ symbol to read, "better than or equal to" **Mission constraints/requirements:** (1) Specifically state baseline and floor coverage. Floor coverage of greater than or equal to 50% added. Modifications based on discussions with Jeff Moore, chair of the geology group, and the Project Scientist.	✔		✔
				G.2b	Regional-scale stereo imaging at ~20–250 m/pixel inbound and outbound on each flyby.	Topographical Imager (TI) (stereo)	(1) Require stereo imaging at incidence angles of ~20° to 80° (baseline range). Desire imaging at solar incidence angles greater than 45°, preferably 70°; (2) Make observations when the solar phase angle is ≤135 degrees. (3) Floor: Sampling in any 8 of the 14 panels, with a total coverage of greater than or equal to 20% of Europa's surface; Baseline sampling in any 11 of the 14 panels, with a total coverage of greater than or equal to 30% of Europa's surface.	**Mission constraints/requirements:** (1) Clarification of the baseline range, (2) "Desire" is the preferred range of incidence angles--based on discussion with the mission design team. (3) Clarification to indicate that the requirement is for **"any"** 8 of the 14 panels for the floor and **"any"** 11 of the 14 panels for the baseline. (4) Additional clarification that the total surface coverage required is greater than or equal to 25% of Europa--discussions within the Project Science team and with SDT Geology group lead Jeff Moore. **Version 2.2** **Mission constraints/requirements:** (1) Specifically state a floor coverage of greater than or equal to 20% of Europa's surface and floor coverage. Baseline coverage increased from 25% to 30%. Modifications based on discussions with Jeff Moore chair of the geology group, and the Project Scientist.	✔		✔

Water Water in its liquid form as

Chemistry The constituents that foster and

Energy Energy that supports and